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Geographical Indication Labels in Moroccan Olive Oil Sector: Territorial Dimension and Characterization of Typicality: A Case Study of Meknès Region

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Additional information is available at the end of the chapter

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Abstract

Geographical indications (GIs) implementation is, nowadays, one of the most prominent differentiation strategies used in olive oil market. The proliferation of these labels, however, causes debate and controversy, in particular regarding their usefulness, effectiveness, and suitability of some protected areas to acquire them. This chapter discusses the use of GI labels in olive oil market, and proposes a four-stage methodological approach to examine the potential of Meknès region—a Moroccan olive growing area—to acquire a GI label. Based on this approach, Meknès region territorial dimensions were defined, the typicality of its olive oil was characterized, a general scheme for the GI recognition was proposed, and the adopted strategy to enhance the meaning of this label on domestic, national, and international markets was highlighted. The main findings of this study justify the suitability of Meknès region to protect its olive oil with a GI label.

Keywords: olive oil, geographical indication, chemical characterization, differentiation marketing strategy, Meknès region

1. Introduction

In the Mediterranean Basin, olive oil production can be considered as a science, but also a combination of creativity and innovation; it is also a lifestyle and a unique and ancestral tradition

passed down through history from one generation to another. This historical interaction between Mediterranean populations, environment, and olive tree cultivation has created a specific cultural identity, which is crucial to understand the emergence and spread of olive tree cultivation and oil production all over the world [1]. It is also very important to mention the fundamental socioeconomic role that olive oil production and trade have played in different parts of the Mediterranean area throughout history.

In many Mediterranean regions, nowadays, an integral form of revitalization, enhancement, and appreciation of the historical legacy of olive oil production is the establishment of geographical indications (GIs). They are often perceived as valuable tools that allow not only the safeguard of their cultural identity, but also to gain market benefits and profitability and competitiveness in a growing olive oil globalized market [2].

GIs are names of places or regions used to brand goods (olive oil in this case) with a distinct geographical connotation, which means that their specific quality attributes are considered to be inherently linked to (or determined by) their geographical origin's characteristics. In this way, olive oil companies, besides using private trademarks, have an excellent opportunity to promote the uniqueness of their products through the use of these labels. Olive oil producers generally demonstrate the quality of this product by regulatory standardized parameters (mainly content of free fatty acids, peroxide value, ultraviolet specific extinction coefficients, and sensory characteristics); in contrast, GIs broaden the olive oil quality concept to added-value attributes such as provenance, local know-how, cultural traditions, and distinctive quality, which can help to differentiate the origin-labeled olive oil among similar products. By adopting these labels, added-value, premium price and a competitive positioning on either traditional or emerging olive oil markets are, obviously, expected. It is also assumed that they can provide rural areas (where they are established) with additional social and economic benefits [3, 4]. Given their importance, an unprecedented recognition of these labels was recorded over the last years in many parts of the Mediterranean area. According to the information published by different organizations [5–9], it is possible to state that till 2015, about 123 olive growing regions have registered their olive oil production under GI schemes; all of them are located in Mediterranean countries, with Italy (43 GIs), Greece (29 GIs), and Spain (28 GIs) at the highest positions of the list.

Because of the rapid proliferation of GIs in the olive oil sector, their usefulness and effectiveness are currently lively debated topics. Within this context, some very successful stories of olive oil GIs can be told (e.g., the Spanish Baena olive oil [10], French GIs olive oils [11], and Italian Toscana olive oil [12], that have achieved a considerably higher price (premium price) than other no GI labeled olive oils). Nevertheless, these cases represent a limited number of examples if compared with the high number of existing GI olive oils. Some authors have expressed reservations in this respect, pointing out the lack of reputation and notoriety of several of these olive oils produced under GI schemes. This would obviously have negative consequences on the overall value of the olive oil GI system [13, 14]. Therefore, it is very important to identify the moment in which implementing an olive oil GI is appropriate, as well as how to benefit from it. As properly stated by Aubard [15], GIs should be adopted as response to an identified (product chain) need, and must be designed pragmatically and

realistically, so as to be useful to the business. Furthermore, the author criticizes the wrong idea that many producers have about GIs, expecting that the label will automatically make the markets more accessible to them. This is not true and any procedure aiming to increase the value of products (such as GI) necessary requires a properly planned management and considerable marketing efforts [15].

Morocco has traditionally been a land of olive tree cultivation and olive oil production, and it currently stands out as one of the most important olive oil producing countries, ranking sixth worldwide [16]. In this country, the olive oil sector is increasingly considered as an economic and social development engine of various regions. Under that perspective, olive oil sector modernization, yield increasing, and olive oil quality enhancement, have been—and remain—a priority in Moroccan agricultural policy [17]. In this respect, the establishment of GIs is the cornerstone of the current Moroccan olive oil quality policy. Protected designations of origin (PDO), protected geographical indications (PGIs), and traditional specialties guaranteed (TSG) are the instruments created for this purpose [18]. Indeed, till 2016, two PDOs and three PGIs have been registered, while some others are in the scrutiny process.

Meknès region is one of these Moroccan olive growing areas that aim to provide their olive oil production with a GI label (particularly, a PDO). With the purpose to contribute to the implementation of this GI label for Meknès olive oil, our research group has carried out a multidisciplinary and pluri-annual study. Other Mediterranean experiences in this field, and the assets and constraints abovementioned that have led to the current scenario (in which some olive oil GIs have experienced exceptional success while others have failed) have been considered. In our study, we basically tackled the following broad questions:

-is setting up a PDO in Meknès region appropriate?

-what should it be done to assure that this label will be long-lastingly effective and not only one more without any interest and benefit?

2. Setting up a Meknès olive oil PDO: methodological approach and main findings

The approach in this study was based on a comprehensive literature review of what drives to successful processes of implementation and valorization of different GIs. Every success factor identified in literature was listed and adapted during our research, with additional insights gained over the study period.

It was found that no universal model exists for a successful GI labels implementation and valorization; there is, indeed, a wide diversity of practices for implementing registered GIs all over the world [19–23]. In addition, literature clearly points out that the process of determining the suitability of a product in a given region to pursue a GI label should be scientifically grounded and built on a robust methodology taking into account the current knowledge in the field. It should be also able to stimulate the participation of all the product supply chain actors in order to integrate different points of view and interests. The concept of GI necessarily

requires the efforts and skills of the different producers and/or processors to build a common vision concerning the quality of the product and the specific characteristics of its production process.

From the beginning, our team was convinced about the fact that the implication of the future Meknès olive oil PDO stakeholders was strongly encouraged and could represent the key to success. We refer to the members of the association “Union pour le Développement de l'Olivier de Meknès (UDOM)”, including farmers, olive oil producers and processors. The scientific approach was designed around the basic definition of a PDO (also called “geographical designation of origin” or “appellations of origin”): *“the geographical denomination of a country, region, or locality, which serves to designate a product originating therein, the quality or characteristics of which are due exclusively or essentially to the geographical environment, including natural and human factors”* [24]. Two features are noteworthy in this definition:

- The first is the fact that a PDO identifies a geographical entity, including natural and human factors. This is commonly designed by the term “terroir”.
- The second is the existence of a link between the quality, characteristics and reputation of the PDO product and the “terroir” where is produced. This refers to the term “typicality”.

Consequently, the implementation of a PDO label should be certainly built on the delimitation of the terroir, the definition of its factors, and the characterization of the typicality of the product.

2.1. A first step toward Meknès virgin olive oil PDO: characterization of “terroir” dimensions

Terroir is a derivative of the French word for soil or land “terre”, that can be conceptualized in several different disciplines [25, 26]. This concept is practically the base of any GI system and many researchers have worked on its definition and the determination of its components [19, 27]. Terroir could be defined as: *a delimited geographical space, where a human community has constructed a collective intellectual or tacit production know-how, based on physical and biological milieu and a set of human factors, which confer a typicality and induce a reputation for a product that originates in that terroir* [28, 29]. What comes out from this definition is that an efficient way of approaching terroir should basically imply the determination of its three dimensions:

- *Geographical dimension*: the natural environment (mainly climate, topography, geology, and soil);
- *Social dimension*: the local know-how, traditions and cultural aspects in relation to the production, trade and use of the product; and
- *Technical dimension*: the agronomical and technological techniques used in the elaboration of the product.

Overall, it can be said that it is the combination and the strong interaction among these three dimensions, which is reflected on the special quality and particular characteristics of a GI product.

2.1.1.1. Meknès terroir geographical dimension

Meknès region is located in the North-Center of Morocco (33°53'36N, 5°32'50W), covering an area of approximately 400,700 ha, including a total olive growing area of 43,000 ha. It is a region with dramatic topographic contrasts and its landscape has a complex geomorphology (**Figure 1**). Climatically, Meknès terroir is situated in a Mediterranean subhumid to semi-arid climatic zone, with cool winter and warm dry summer. Rainfall is mostly uniformly distributed over the year. On average, this terroir annually receives 400–600 mm of rainfall, which is favorable for various crops, including olive tree. Meknès soils are constituted by fluvisols, regosols, lithosols, rendzinas, yermosols, xerosols, vertisols, kastanozems, chernozems, phaezems, luvisols, and acrisols, varying in thickness, depending on the depth of the substrate and the old and recent manifestations of anthropogenic erosion and runoff.

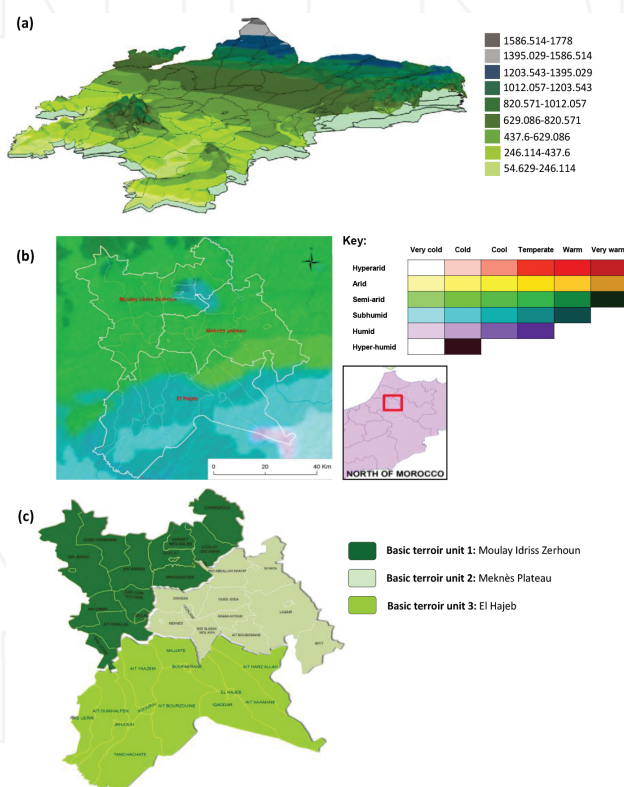


Figure 1. Meknès terroir geographical dimension construction: (a) altitude map; (b) climate map; (c) Meknès terroir delimitation showing the localization of the three basic terroir units identified.

The first step in the characterization of the geographical dimension of Meknès terroir has revealed a relatively complex variability of natural environmental factors in this area,

which can affect the homogeneity of qualitative and compositional profile of the olive oils obtained in this terroir. Therefore, the identification of basic terroir units (homogenous geographical areas, from the environmental point of view) inside this region was the following step. The model proposed by Morlat [30] was used for that. Practically, each unit is defined by three associated components: a geological component, a pedoclimatic element and a landscape component. Therefore, the workflow of this methodology involved three main tasks:

- Delimitation, characterization and cartography of Meknès terroir.
- Characterization of the landscape and pedoclimatic conditions in this terroir.
- A multifactorial analysis which integrates all the results obtained from the first two activities and allows the determination of the basic terroir units.

Thus, by applying this methodology, it was possible to identify three basic terroir units in Meknès region: Moulay Idriss Zerhoun, Meknès Plateau, and El Hajeb (**Figure 1**).

2.1.2. Social dimension of Meknès terroir

Once the geographical dimension of Meknès terroir was defined, a careful investigation of ancient documents, archive maps and books that report the history of olive tree and oil production in this territory was made. Gastronomy habits and ancient practices and uses of this product throughout the history of Meknès were also documented. Finally, historical structures and archeological evidences which testify the long-standing olive growing and oil production practices in this zone were explored and inventoried.

It was clearly demonstrated that Meknès region constitutes the cradle of olive tree cultivation and oil production in Morocco, since the oldest evidence of these practices in this country (dating for the roman era, about 2000 years ago) are found in this area (Moulay Idriss Zerhoun area and the archaeological site of Volubilis).

2.1.3. Technical dimension of Meknès terroir

At this point, we analyzed the olive-growing and olive oil processing sector characteristics of Meknès terroir. The work was firstly based on the study of data coming from the national and local institutions in charge of agriculture development, and, then, several surveys were performed among farmers and olive oil processors. The surveys focused on olive-growing farms were conducted to characterize the practiced agronomical techniques for the management of olive orchards (mainly planted olive varieties, plantation density, soil management, irrigation, fertilization, pruning, disease management, and harvesting), and also to evaluate the productivity of the olive orchard. The collected data were analyzed in depth and allowed to distinguish four main different olive growing cultivation systems: traditional rainfed, intensive rainfed, intensive irrigated, and superintensive system (**Figure 2**), with 93.4% of Meknès olive orchard planted using “Picholine Marocaine” cultivar.



Figure 2. Olive growing cultivation systems in Meknès: (a) traditional rainfed; (b) intensive rainfed; (c) intensive irrigated; (d) superintensive system.

A second type of surveys focused on olive oil mills. The collected data were compiled in a geo-database and integrated with digital maps of Meknès region (**Figure 3**). A total of 245 olive oil mills were listed; 102 of them were traditional processing mills, so-called massars, 91 semi-moderns oil mills, and 52 moderns oil mills (28 two-phase and 24 three-phase). Regardless of the number of mills of each type, most of the produced olive oil is made by modern mills, showing a mean processing capacity of 3533.6 t/day. Furthermore, all the olive oils commercialized in package are coming from these mills.

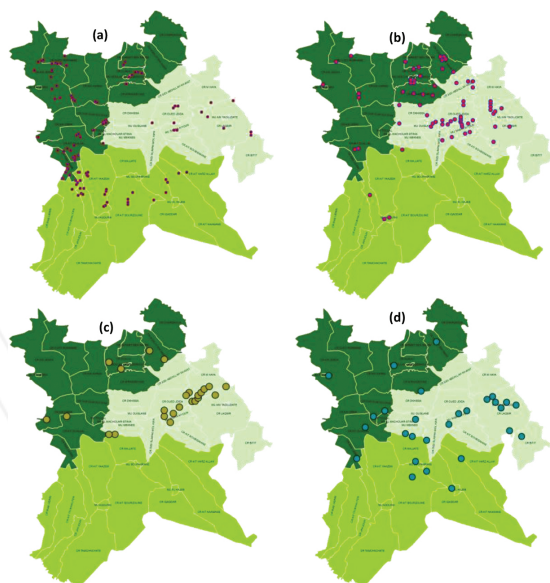


Figure 3. Geographical localization maps of Meknès olive oil mills: (a) traditional; (b) semimodern; (c) three-phase; (d) two-phase.

The first phase of the study was, therefore, accomplished, and, the territorial dimensions of Meknès region had been characterized. The obtained results logically conditioned the selected methodological approach to carry out the second stage of the project, in particular, regarding the selection and collection of olive oil samples for the determination of the typicality of Meknès olive oil.

2.2. Characterization of typicality of Meknès virgin olive oil

2.2.1. The typicality concept: definition, dimensions and attributes

According to the definition of the concept of typicality of an agricultural product, this term means: *“the property of belonging to a particular type defined and recognized as such by a specific human group, the different members of which have acquired areas of knowledge or know-how relative to their role in the production process. Know-how, then, as regards the setting up of the process, and the making, testing and tasting of the product. [...] It is a particular construction that aims to materialize the effect of the land on a given product”* [28]. Inspired by this definition, various authors describe as mandatory the determination of a set of properties of belonging (level of representativeness of an item in a category) and distinction (properties that make possible to differentiate, identify, and recognize the product among others similar) for the ascertainment of the typicality of a product [31, 32].

2.2.2. Typicality of Meknès virgin olive oil: findings of the main studies

Based on the previous definition, the evaluation of the typicality of Meknès olive oil was performed by determining:

-Its properties of belonging: by assessing the qualitative and compositional profile of olive oils produced within Meknès region. It was expected that the olive oils produced in this area would show some differences among them, but sharing certain common characteristics. Indeed, the determination of these common features could allow defining the “typical” olive oil produced in this region. If this “typical profile” would differ among the three basic terroir units identified, there will be no way to consider the whole Meknès region as an eligible area to be certified by a PDO scheme.

-Its properties of distinction: which involves the characterization and identification of qualitative and compositional properties of Meknès olive oils that distinguish them among others oils produced outside this terroir. It is a question of identifying the uniqueness and singularity of the oils produced in Meknès region.

In the coming paragraphs, we will try to briefly summarize the most relevant results from some of the research projects which have been carried out (or are ongoing) within our lab involving the use of different analytical techniques and the determination of the physico-chemical and sensory quality, as well as other compositional parameters (such as phenolic compounds, triacylglycerols, and volatile compounds).

For the determination of Meknès olive oil properties of belonging, two pluri-annual studies were carried out. The first work aimed the characterization of the physicochemical and organoleptic quality and compositional profile of 298 olive oil samples from “Picholine Marocaine” cultivar, obtained from 12 industrial olive oil mills, located in the three identified basic terroir units. Both variations induced by crop season and those expected between the three basic terroir units were assessed over four consecutive crop seasons (from 2010 to 2013). The results obtained reveal that, besides an interannual variation, olive oils produced in Meknès region are characterized by high physicochemical and sensory quality, as well as a homogeneous composition regardless of the production subarea. Considering their sensory quality, all the analyzed samples were classified as extra virgin olive oils, according to IOC regulations. **Figure 4** depicts the standard/average sensory profile of the studied samples, having two categories: intense fruitiness and medium fruitiness. More details can be found in [33].

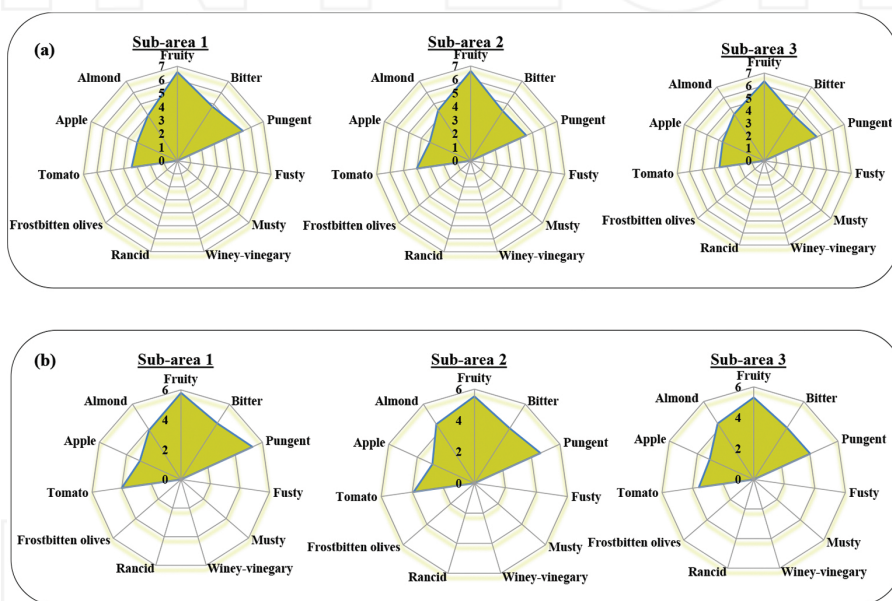


Figure 4. Sensory averaged profiles of Meknès monovarietal olive oils: (a) intense fruitiness profile; (b) medium fruitiness profile (reproduced with permission from [33]).

In the second study [34], particular attention was paid to the characterization of phenolic compounds from oils produced in Meknès region. These compounds are of unquestionable importance since they have a noticeable influence on some olive oil sensory characteristics and biological properties [35, 36]. These reasons made us going for their characterization in Meknès olive oils. The study was conducted over three consecutive crop seasons (2011, 2012, and 2013) on 142 “Picholine Marocaine” olive oil samples obtained by extracting olive fruits collected from orchards located on the three Meknès basic terroir units. A liquid chromatography-mass

spectrometry platform was used to this purpose. A total of 28 phenolic compounds (and quinic acid) were determined, revealing the complex profile of Meknès virgin olive oil, composed, in order of abundance, by secoiridoids, phenolic alcohols, lignans, flavonoids, and phenolic acids. Results showed that the variation of the content of phenolic compounds was mainly related to the crop season, which proves, once again, the homogenous character of the profile of olive oils produced in the entire Meknès terroir. **Table 1** shows some of the quantitative results obtained in this study, showing the mean \pm standard deviation (mg/kg) of phenolic compounds, grouped by chemical categories.

| Chemical category | Crop season 2011 | | | Crop season 2012 | | | Crop season 2013 | | |
|-------------------|-------------------------------------|--------------------------------------|--------------------------------------|-------------------------------------|---|---|---|--|--|
| | Subarea 1 (<i>n</i> = 13) | Subarea 2 (<i>n</i> = 15) | Subarea 3 (<i>n</i> = 15) | Subarea 1 (<i>n</i> = 11) | Subarea 2 (<i>n</i> = 16) | Subarea 3 (<i>n</i> = 7) | Subarea 1 (<i>n</i> = 24) | Subarea 2 (<i>n</i> = 9) | Subarea 3 (<i>n</i> = 32) |
| Simple phenols | 10.22 ^a \pm 7.97 | 13.07 ^a \pm 6.98 | 11.19 ^a \pm 7.02 | 10.19 ^a \pm 2.63 | 8.77 ^a _{ab} \pm 2.98 | 7.64 ^a _{ab} \pm 1.78 | 8.11 ^a \pm 4.83 | 7.51 ^b \pm 3.95 | 6.90 ^b \pm 3.15 |
| Lignans | 5.34 ^a \pm 2.16 | 4.08 ^a \pm 2.23 | 4.41 ^a \pm 2.96 | 2.99 ^b \pm 3.25 | 4.09 ^a _{ab} \pm 5.83 | 2.19 ^a \pm 2.12 | 1.43 ^b \pm 0.87 | 1.58 ^b \pm 0.42 | 3.08 ^a \pm 4.77 |
| Flavonoids | 1.55 ^a \pm 1.17 | 3.23 ^a \pm 3.18 | 3.15 ^a \pm 2.47 | 1.40 ^a \pm 0.24 | 1.57 ^a _{ab} \pm 0.76 | 2.10 ^a _{ab} \pm 1.1 | 1.38 ^a _b \pm 0.5 | 1.10 ^b \pm 0.29 | 1.63 ^b \pm 0.67 |
| Phenolic acids | 0.13 ^a \pm 0.09 | 0.22 ^a \pm 0.15 | 0.22 ^a \pm 0.27 | 0.18 ^a \pm 0.07 | 0.19 ^a \pm 0.14 | 0.22 ^a \pm 0.15 | 0.18 ^a \pm 0.09 | 0.17 ^a \pm 0.07 | 0.21 ^a \pm 0.15 |
| Secoiridoids | 704.59 ^a \pm 361.56 | 1018.01 ^a \pm 524.23 | 1106.96 ^a \pm 553.85 | 594.50 ^a \pm 175.16 | 706.15 ^a _{ab} \pm 218.98 | 831.46 ^a _{ab} \pm 363.83 | 684.64 ^a \pm 177.52 | 540.12 ^a _b \pm 158.91 | 688.14 ^a _b \pm 253.54 |
| Other compounds | 1.04 ^a \pm 1.05 | 12.87 ^b \pm 16.60 | 9.34 ^b \pm 15.2 | 2.80 ^a \pm 3.89 | 0.51 ^b \pm 0.53 | 1.32 ^a _b \pm 1.18 | 1.84 ^a \pm 2.35 | 5.48 ^a \pm 12.38 | 2.34 ^b \pm 3.83 |

-Significant differences in the same row are indicated with different lowercase letters (comparison among crop seasons, $p < 0.05$) and with different superscript letters (comparison among subareas at the same crop season, $p < 0.05$).

-The different categories included the sum of the individual amount of the following compounds: simple phenols (hydroxytyrosol, tyrosol, and oxidized hydroxytyrosol), lignans (pinosresinol, acetoxypinosresinol, and syringaresinol), flavonoids (luteolin and apigenin), phenolic acids (*p*-coumaric acid), secoiridoids (decarboxymethylated form of elenolic acid, desoxy elenolic acid, elenolic acid, decarboxymethyl oleuropein aglycone, methyl decarboxymethyl oleuropein aglycone, decarboxymethyl ligstroside aglycone, dehydro oleuropein aglycone, oleuropein aglycone (and its isomers), methyl oleuropein aglycone, and ligstroside aglycone (and its isomers)), and other compounds (quinic acid).

-Quinic acid, hydroxytyrosol, tyrosol, pinosresinol, luteolin, apigenin, and *p*-coumaric acid were quantified in terms of their commercial pure standards. Oxidized hydroxytyrosol was quantified in terms of hydroxytyrosol; lignans, in terms of pinosresinol; and secoiridoids with oleuropein.

-Mean values are those calculated for all the samples coming from the same subarea and crop season, therefore, standard deviation gives to the reader only an idea about the variability of the olive oils in terms of composition, and obviously not about the repeatability of the analytical methods used. (The same is applicable to **Table 2** regarding the different provenance regions.)

Table 1. Mean \pm standard deviation (mg/kg) of phenolic compounds determined in Meknès monovarietal virgin olive oils.

With regard to the properties of distinction of Meknès olive oils, various phenolic compounds profiling studies (combining compositional data and chemometric treatments) were performed in an attempt to discriminate the olive oils produced in Meknès terroir from others

produced outside this region. Within this context, the potential of merging quality and chemical profiles data and multivariate statistical analysis was tested on 279 olive oil samples (among which 69 were from Meknès region and the others were collected from six North Moroccan regions). The obtained chemometric models were able to correctly discriminate Meknès olive oils from the rest, with rate of 100% and 91.30% in recognition and prediction abilities, respectively [37].

In another work carried out on the same samples set, the triacylglycerols (TAG) fraction was determined and chemometric data analysis (including principal components analysis (PCA), linear discriminant analysis (LDA), partial least squares-discriminant analysis (PLS-DA), and soft independent modeling of class analogies (SIMCA)) was used to differentiate the studied samples according to their geographical origin. Twenty one TAGs were characterized and the variability observed among the studied samples could be related to the production area. The mean concentration and standard deviation (mean \pm SD (%)) for the TAGs identified in the studied North Moroccan olive oil samples are listed in **Table 2**.

| | Chefchaouane | Fès | Meknès | Ouazzane | Sefrou | Taounate | Taza |
|--------------|----------------------|--------------------|--------------------|---------------------|--------------------|-------------------|--------------------|
| | Mean \pm SD | | | | | | |
| ECN42 | | | | | | | |
| LLL | 0.05a \pm 0.02 | 0.41b \pm 0.14 | 0.14a \pm 0.06 | 0.28c \pm 0.13 | 0.11a \pm 0.03 | 0.25c \pm 0.09 | 0.14a \pm 0.06 |
| OLLn + PoLL | 0.35a \pm 0.13 | 0.52b \pm 0.17 | 0.37a \pm 0.09 | 0.50b \pm 0.03 | 0.37a \pm 0.06 | 0.38a \pm 0.07 | 0.48b \pm 0.09 |
| PLLn | 0.07ac d \pm 0.03 | 0.11b \pm 0.03 | 0.08c \pm 0.03 | 0.10b \pm 0.01 | 0.06d \pm 0.01 | 0.08c \pm 0.02 | 0.07acd \pm 0.02 |
| Total ECN 42 | 0.58ade \pm 0.29 | 1.04b \pm 0.30 | 0.59ad \pm 0.14 | 0.88c \pm 0.16 | 0.54d \pm 0.09 | 0.71e \pm 0.15 | 0.70ae \pm 0.16 |
| ECN44 | | | | | | | |
| OLL | 2.96ade \pm 0.88 | 4.80b \pm 0.88 | 2.41cd \pm 0.71 | 3.45a \pm 0.91 | 2.08c \pm 0.51 | 3.52a \pm 0.75 | 2.90e \pm 0.63 |
| OLLn | 1.58ab \pm 0.21 | 1.79a \pm 0.26 | 1.68a \pm 0.32 | 1.77a \pm 0.04 | 1.76a \pm 0.06 | 1.47b \pm 0.17 | 2.13c \pm 0.19 |
| PLL | 0.46a \pm 0.27 | 0.90b \pm 0.54 | 0.48a \pm 0.14 | 0.85b \pm 0.14 | 0.45a \pm 0.1 | 0.46a \pm 0.07 | 0.76b \pm 0.17 |
| POLn | 0.63ab \pm 0.13 | 0.66a \pm 0.16 | 0.66a \pm 0.14 | 0.66ab \pm 0.10 | 0.58b \pm 0.03 | 0.43c \pm 0.08 | 0.76d \pm 0.11 |
| Total ECN 44 | 5.03ade \pm 1.64 | 8.16b \pm 1.61 | 5.24ad \pm 0.99 | 6.73c \pm 0.72 | 4.87d \pm 0.64 | 5.88e \pm 0.83 | 6.54ec \pm 0.80 |
| ECN46 | | | | | | | |
| OOL + PPLn | 14.23ace \pm 3.79 | 19.03b \pm 1.19 | 14.91ce \pm 1.68 | 16.87dfg \pm 1.49 | 15.01eg \pm 1.58 | 17.72f \pm 1.42 | 16.07g \pm 1.34 |
| PoOO | 1.19abde \pm 0.38 | 1.28abe \pm 0.22 | 1.17ad \pm 0.14 | 1.12acd \pm 0.18 | 0.91f \pm 0.12 | 1.31ae \pm 0.14 | 1.01acf \pm 0.16 |
| SLL+PLO | 4.62acd \pm 1.43 | 5.85e \pm 1.00 | 5.41ae \pm 1.26 | 6.58b \pm 0.46 | 4.71cd \pm 0.46 | 4.57d \pm 0.49 | 5.41ae \pm 0.67 |
| PoOP | 0.72abcde \pm 0.35 | 0.84abc \pm 0.50 | 0.96b \pm 0.42 | 0.67c \pm 0.30 | 0.42de \pm 0.06 | 1.01b \pm 0.20 | 0.37e \pm 0.24 |

| | Chefchaouane | Fès | Meknès | Ouazzane | Sefrou | Taounate | Taza |
|--------------|-----------------|---------------|-----------------|-----------------|----------------|----------------|----------------|
| | Mean ± SD | | | | | | |
| Total ECN 46 | 20.76ace ± 4.84 | 27.00b ± 1.64 | 22.45c ± 2.85 | 25.24d ± 1.65 | 21.05e ± 1.93 | 24.61d ± 1.94 | 22.86ac ± 1.89 |
| ECN48 | | | | | | | |
| PLP | 0.44ad ± 0.05 | 0.38b ± 0.04 | 0.42a ± 0.04 | 0.38c ± 0.01 | 0.45d ± 0.02 | 0.44d ± 0.02 | 0.40a ± 0.03 |
| OOO | 45.62ac ± 4.71 | 39.33b ± 4.11 | 43.20ac ± 4.00 | 39.62b ± 0.83 | 46.67ad ± 2.03 | 45.33ad ± 2.54 | 41.91c ± 2.77 |
| SOL | 0.55ace ± 0.08 | 0.47b ± 0.06 | 0.57ce ± 0.06 | 0.55ac ± 0.05 | 0.52ae ± 0.03 | 0.43d ± 0.03 | 0.55e ± 0.04 |
| POP | 2.63abde ± 0.84 | 2.25b ± 0.64 | 2.94ade ± 0.76 | 2.89de ± 0.57 | 2.42ab ± 0.20 | 1.67c ± 0.35 | 2.94d ± 0.50 |
| POO | 18.37ace ± 2.81 | 15.79b ± 1.86 | 19.33ce ± 1.90 | 18.54ace ± 1.73 | 17.61ae ± 0.84 | 14.64d ± 0.97 | 18.58e ± 1.28 |
| Total ECN 48 | 67.61ac ± 6.42 | 58.22b ± 2.69 | 66.46a ± 3.58 | 61.99d ± 2.48 | 67.68a ± 2.77 | 62.51cd ± 2.79 | 64.39c ± 2.72 |
| ECN50 | | | | | | | |
| SOO | 5.12ac ± 1.30 | 4.81ad ± 0.82 | 4.47a ± 0.63 | 4.28b ± 0.24 | 5.04ad ± 0.55 | 5.53c ± 0.81 | 4.66abd ± 0.62 |
| POS | 0.79abcd ± 0.09 | 0.75ad ± 0.08 | 0.79abcd ± 0.11 | 0.85bc ± 0.1 | 0.82c ± 0.07 | 0.76d ± 0.14 | 0.78acd ± 0.09 |
| Total ECN 50 | 5.91abc ± 1.35 | 5.56ac ± 0.85 | 5.26c ± 0.70 | 5.13c ± 0.27 | 5.86ab ± 0.61 | 6.29b ± 0.90 | 5.44ac ± 0.68 |

Reproduced with permission from [38].
-ECN: equivalent carbon number.
-TAG names are abbreviated by means of three letters corresponding to the FA bound to the glycerol backbone. In alphabetic order: L, linoleic acid (C18:2); Ln, linolenic acid (C18:3); O, oleic acid (C18:1); P, palmitic acid (C16:0); Po, palmitoleic acid (C16:1); and S, stearic acid (C18:0).
-Significant differences within the same line are indicated with different lowercase letters (comparison between studied regions, $p < 0.05$).

Table 2. Quantitative results (mean ± standard deviation, %) for TAGs in the studied samples considering the provenance region.

LDA and PLS-DA were the statistical treatments which gave the best results (in terms of accuracy for both training and test sets), but also the other classification procedure used (SIMCA) achieved a satisfactory and correct geographical classification. It was demonstrated that, for most of the considered regions in the study, useful information could be extracted from TAG data for the geographical discrimination of their virgin olive oils. When considering Meknès terroir samples, rates of 93.48% in both classification and cross-validation and 82.61%, in external validation, were obtained [38].

In addition, a phenolic compounds profiling approach was applied to discriminate Meknès olive oils (36 samples) from those produced in six North Moroccan regions (120 samples) [39]. The developed methodology (using liquid chromatography coupled to mass spectrometry and a discriminant data analysis treatment) allowed differentiating 100% of Meknès samples in

recognition and 91.67% of them in prediction. Besides, a similar approach was used to discriminate Meknès olive oil from those coming from two existing olive oil GIs in Morocco (PGI Ouazzane and PDO Tyout-Chiadma) [40]. In the just cited contribution, 136 commercial extra virgin olive oil samples were collected and their phenolic profile was characterized. Typical Base Peak Chromatograms of the methanolic extracts of representative samples from the three studied regions are shown in **Figure 5**.

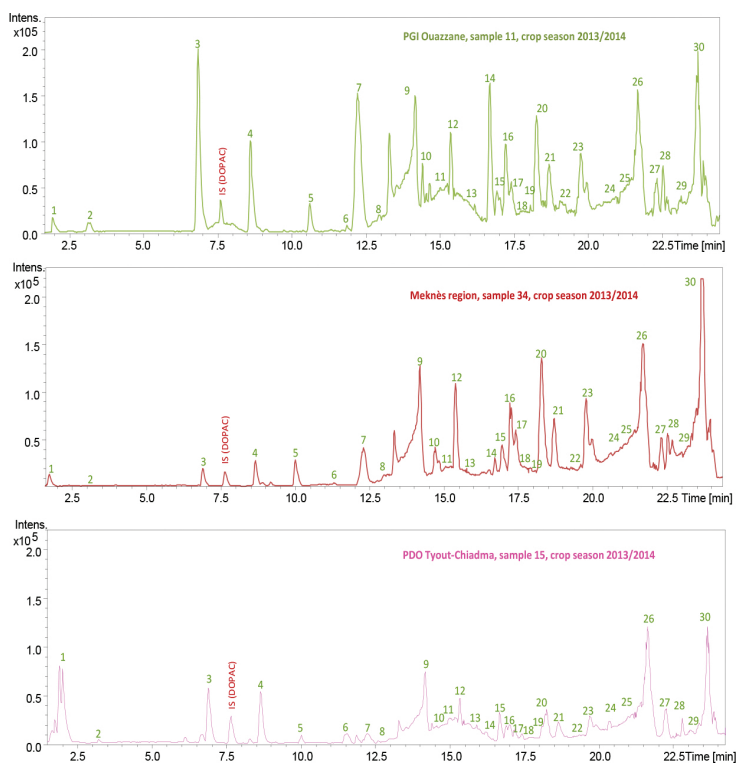


Figure 5. Base peak chromatograms typical for Meknès, PGI Ouazzane, and PDO Tyout-Chiadma extra virgin olive oils samples. Peak identification: (1) quinic acid; (2) oxidized hydroxytyrosol; (3) hydroxytyrosol; (4) tyrosol; (5) dialdehydic form of decarboxymethyl elenolic acid; (6) *p*-coumaric acid; (7) desoxy elenolic acid; (8) hydroxy elenolic acid; (9) elenolic acid; (10) oleuropein aglycone isomer 1; (11) dialdehydic form of decarboxymethyl oleuropein aglycone; (12) oleuropein aglycone isomer 2; (13) syringaresinol; (14) luteolin; (15) oleuropein aglycone isomer 3; (16) ligstroside aglycone isomer 1; (17) pinorensinol; (18) acetoxypinorensinol; (19) methyl decarboxymethyl oleuropein aglycone; (20) oleuropein aglycone isomer 4; (21) dialdehydic form of decarboxymethyl ligstroside aglycone; (22) apigenin; (23) oleuropein aglycone isomer 5; (24) ligstroside aglycone isomer 2; (25) dehydro oleuropein aglycone; (26) oleuropein aglycone; (27) oleuropein aglycone isomer 6; (28) ligstroside aglycone isomer 3; (29) methyl oleuropein aglycone; (30) ligstroside aglycone (reproduced with permission from [40]).

When statistical tools were applied for data treatment, the results were very satisfactory, since the 57 samples belonging to Meknès terroir were 100% correctly classified and 94.70% accurately predicted.

The potential of volatile compounds (determined by gas chromatography coupled to mass spectrometry) combined to chemometric data analysis was also tested to distinguish Meknès olive oils from other olive oil samples produced in diverse Moroccan zones. Among the 92 samples analyzed, very good rates of classification (100%), and prediction (90.48%) were obtained for the 21 studied samples from Meknès region [41].

In general, the good discriminant rates achieved within all the above-mentioned studies, as well as the identified geographical markers demonstrate, from our point of view, the uniqueness and specificity of the olive oil produced in Meknès region.

We can conclude this section stating that, in light of the results obtained by the summarized studies in which about 967 samples were analyzed, the typicality of Meknès olive oil was properly characterized, defining, at the same time, an average qualitative and compositional profile of these oils. Their distinctive characteristics were compared to other Moroccan olive oils. The information obtained within these studies was (and is being) of great practical use in redacting the specifications report.

3. General scheme for the recognition of Meknès virgin olive oil PDO

Once the potential of Meknès olive oil to be certified under a PDO scheme was verified, the next step was the elaboration of a general scheme to be applied for registration in front of the relevant authorities. **Figure 6** briefly illustrates the main activities undertaken within this stage of the study. Working sessions were arranged with the producers of the future PDO and articulated around four actions:

- *Preparation of the production specifications*: a manual containing all the relevant information about Meknès olive oil, as well as a clear description of the practices to be complied with (and those not permitted) along the production chain of this product was prepared. This manual includes the name of the product “Meknès olive oil”; definition of the geographical area of Meknès region; description of the raw materials and the main organoleptic and physicochemical characteristics of Meknès olive oil; information justifying the link with the geographical area, etc.
- *Elaboration of the internal monitoring system*: corresponding to a plan which details *in-situ* controls and documents that should be adopted (and filled in) by Meknès olive oil producers to check the activities, techniques and processes employed during the elaboration of this product.
- *Elaboration of the external monitoring system*: details the main points to be checked and the relevant evaluation methods to be used for ensuring compliance with specifications (logically made with the assistance of an accredited certification body).
- *Definition of specific rules* concerning packaging and labeling of the future Meknès olive oil PDO.

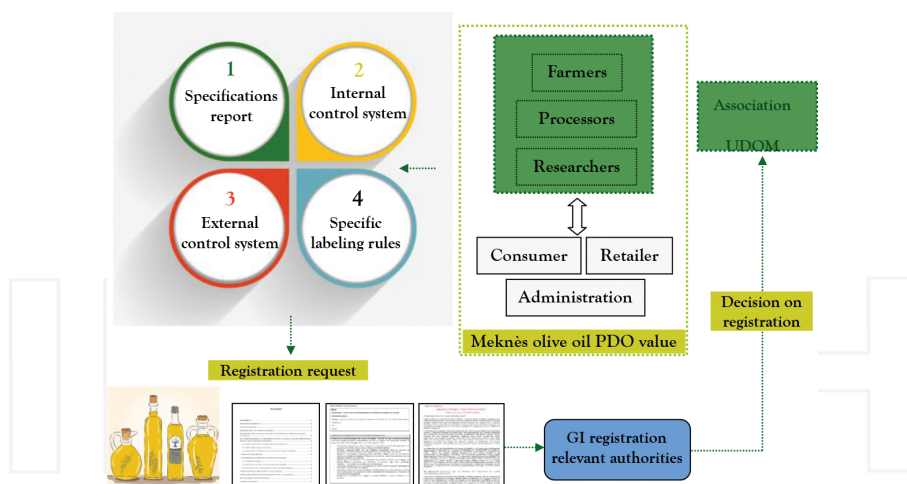


Figure 6. Proposed scheme for Meknès virgin olive oil PDO recognition.

All the elaborated documents were given to the Meknès olive oil PDO stakeholders to start the procedure to apply for the official registration (in front of the relevant authorities). The further procedure for the registration is set out in Food and Agriculture Organization of the United Nations [42].

The official recognition of Meknès olive oil PDO cannot be, however, considered the end of the process, it is rather the beginning of a huge amount of work to maintain, monitor, and promote this PDO. The acquisition of this label is not the goal itself; the final objective is the creation of added-value products and benefits for Meknès farmers and olive oil producers, enhancing, therefore, the access to national and international markets.

As clearly emphasized within this chapter, the success of the PDO label—in Meknès or anywhere else—widely depends on proper implementation, management and further marketing and promotional strategies to intensify its effectiveness. To that end, specific emphasis has to be made on the promotion of Meknès olive oil PDO within the communication charter and action plans jointly elaborated by the association UDOM and other public and private organisms.

4. Enhancement of the effectiveness of PDO Meknès: promoting a terroir through olive tree and olive oil

The regional charter for promoting Meknès terroir through the olive tree and its products reflects a common ambition (shared by all the participants) to make olive growing and oil production activities the basis of the economic regional development. It summarizes a collective vision derived from the alliance between different institutions that take part in the

olive oil sector advancement in this region. Their intention is to stimulate cultural, touristic and commercial activities in a way which will be advantageous for all regional partners. Mechanisms to accomplish these objectives could be principally structured around the following actions:

- Development of common activities to improve cost-effectiveness of management, marketing and promotion of Meknès olive oil;
- Implementation of a cooperative communication (regional, national, and international) strategy;
- Organization of promotional events around the culinary uses of olive oil with special emphasis on Meknès olive oil characteristics;
- Promotion of the health benefits of olive oil, standing out the Meknès olive oil composition and its richness on bioactive compounds;
- Enhancement of the reputation of Meknès PDO olive oil on domestic, regional and international markets (by means of promotional video materials and publicity spots, flyers, Meknès olive oil route map, websites, international fairs, exhibitions, sensory competitions, or other events to promote a more appealing image of Meknès olive oil);
- Organization of Meknès olive oil festival (trade show);
- Organization of a national sensory quality competition with the participation of well-known international experts;
- Membership in other related domestic and foreign olive oil organizations;
- Supporting the development of olive oil tourism in Meknès region.

The strategy is already getting positive effects on Meknès olive oil regarding its recognition on the international market (oils from this region are listed among the best ones worldwide in specialized manuals and guides) and the premium prices achieved by regional producers in national and international markets.

5. Conclusions

The current situation of the use of GI labels all over the world has been discussed, paying particular attention on their usefulness for achieving consumers' recognition, quality signaling, control, and differentiation, and competitive benefits to producers. Moreover, the main factors that affect the success or failure of these geographical labeling schemes and the support needed to make them effective have been underlined. After a general analysis, we asserted that what makes GIs both feasible and operationally effective is the methodological approach followed for their setting up and the capacity of stakeholders to collectively manage, promote, and transform territorial resources into quality attributes recognized by consumers.

We have used Meknès olive oil as example to contextualize the matter and suggest a methodology to define the properties of belonging and distinction of the oils from this region,

supporting the implementation of a PDO label. Our approach involved the use of different analytical techniques and the determination of the physicochemical and sensory quality, as well as other compositional parameters (such as phenolic compounds, triacylglycerols, and volatile compounds) of the oils. Within this plan of action, the suitability of this region to acquire a PDO label was verified and a cooperative management, marketing, and promotion strategy adopted. We really believe that the proposed methodology could be of great importance and assistance to better guide olive oil GI labels implementation, both inside and outside Morocco.

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